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(71) Applicant: **NOKIA TECHNOLOGIES OY** [FI/FI]; Karaportti 3, 02610 Espoo (FI).

(71) Applicant *(for LC only)*: **NOKIA USA INC.** [US/US]; 200 South Mathilda Ave., Sunnyvale, CA 94086 (US).

(72) Inventors: **SCHOBER, Karol**; Laurinniityntie 12 A1, 00440 Helsinki (FI). **LINDH, Lars Erik**; Ulfsbyvagen 19 F 22-23, 00350 Helsinki (FI). **HUGL, Klaus**; Kaiserstrasse 71/1/12, A-1070 Wien (AT).

(74) Agent: **HARRINGTON, Mark F.** et al.; Harrington & Smith, Attorneys at Law, LLC, 4 Research Drive, Shelton, CT 06484-6212 (US).

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(57) Abstract: In accordance with the example embodiments of the invention there is configuring a short physical downlink control channel with common search space candidates for at least one user device; scheduling devices in a downlink or uplink; assigning resources to carry fast downlink control information for each device in search space candidates; and send with the assigned short physical downlink control channel resources the fast downlink control information, including an indication of the assigning and of a short physical downlink shared channel for each device scheduled in a downlink. Further, in accordance with the example embodiments there is receiving a configuration of a short physical downlink control channel with common search space candidates; receiving fast downlink control information, including an indication of assigning of each scheduled device in an downlink or uplink and an indication of an assigned short physical downlink shared channel; and determining resources of the assigned channel.

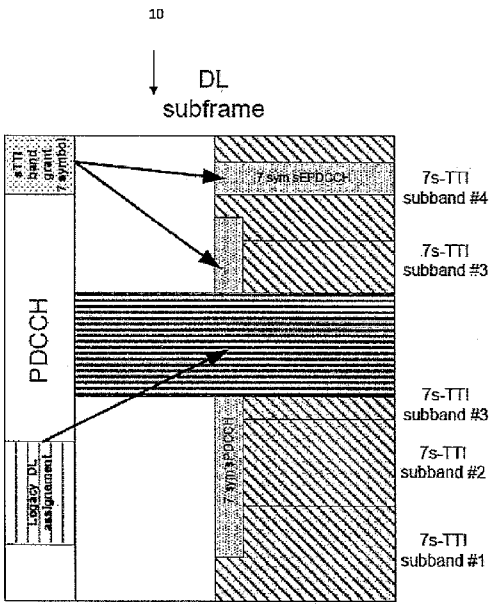

Figure 1

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REDUCTION OF SHORT PDCCH OVERHEAD

TECHNICAL FIELD:

[0001] The teachings in accordance with the example embodiments of this invention relate generally to LTE-Advanced Pro system and, more specifically, relate to latency reduction for 3GPP LTE.

BACKGROUND:

[0002] This section is intended to provide a background or context to the invention that is recited in the claims. The description herein may include concepts that could be pursued, but are not necessarily ones that have been previously conceived or pursued. Therefore, unless otherwise indicated herein, what is described in this section is not prior art to the description and claims in this application and is not admitted to be prior art by inclusion in this section.

[0003] Certain abbreviations that may be found in the description and/or in the Figures are herewith defined as follows:

AL	aggregation level
BD	blind decodes
CCE	Control Channel Element
DCI	downlink control information
DL	downlink
eNB	base station
EPDCCH	enhanced physical downlink control channel
PDSCH	physical downlink shared channel
sPDSCH	short physical downlink shared channel
sPDCCH	short physical downlink control channel
SS	solution set

sTTI	short transmission time interval
UE	user equipment, user device
UL	uplink

[0004] To support the transmission of downlink and uplink transport channels Downlink Shared Channel (DL-SCH) and Uplink Shared Channel (UL-SCH) control signaling is needed. This control signaling enables a UE to successfully receive, demodulate, and decode the shared channel information. The Downlink Control Information (DCI) is transmitted through the Physical Downlink Control Channel (PDCCH) and includes information about the DL-SCH resource allocation (e.g., a set of resource blocks containing the DL-SCH) and a transport format.

[0005] The example embodiments of the invention work provide novel operations for at least operations related to resource allocation using sPDCCH.

SUMMARY:

[0006] In an example aspect of the invention, there is an apparatus, such as a network side apparatus, comprising: at least one processor; and at least one memory including computer program code, where the at least one memory and the computer program code are configured, with the at least one processor, to cause the apparatus to at least: configure a short physical downlink control channel with common search space candidates for at least one user device; schedule the at least one user device in a downlink or uplink; assign resources of the short physical downlink control channel to carry fast downlink control information for each of the at least one scheduled user device in the common search space candidates; and send with the assigned short physical downlink control channel resources the fast downlink control information, wherein the fast downlink control information comprises an indication of the assigning of all scheduled users and an indication of a short physical downlink shared channel for the each of at least one scheduled user device scheduled in a downlink.

[0007] In another example aspect of the invention, there is a method comprising configuring a short physical downlink control channel with common search space

candidates for at least one user device; scheduling the at least one user device in a downlink or uplink; assigning resources of the short physical downlink control channel to carry fast downlink control information for each of the at least one scheduled user device in the common search space candidates, and sending with the assigned short physical downlink control channel resources the fast downlink control information, wherein the fast downlink control information comprises an indication of the assigning of all scheduled users and an indication of a short physical downlink shared channel for the each of at least one scheduled user device scheduled in a downlink.

[0008] A further example embodiments is a method comprising the method of the previous paragraph, wherein the common search space candidates are mutually non-overlapping, wherein the configuring comprises grouping the common search space candidates based on their aggregation level, wherein the grouping of the candidates comprises at least one of labelling and ordering the candidates within each group in a logical manner, wherein the assigning of the resources to carry the fast downlink control information in the common search space candidates occurs continuously in a logical manner within each aggregation level group, wherein the logical manner comprises starting from a common search space candidate with a lowest index, wherein the assigning contains an index of at least one of a last allocated common search space candidate and a first free common search space candidate within each aggregation level group, wherein the indication of the assigning contains a fixed amount of bits, wherein not all the common search space candidate groups are indicated by the fixed amount of bits, wherein the common search space candidate groups with a higher aggregation level are indicated with a higher priority, and/or wherein the short physical downlink shared channel is mapped to resources of the short physical control channel candidates which are indicated as being unassigned and intersect with short physical downlink shared channel resource allocation.

[0009] A non-transitory computer-readable medium storing program code the program code executed by at least one processor to perform the operations as at least described in the paragraphs above.

[0010] In yet another example aspect of the invention, there is an apparatus comprising: means for configuring a short physical downlink control channel with common search space candidates for at least one user device; means for scheduling the at least one user device in a downlink or uplink; means for assigning resources of the short physical downlink control channel to carry fast downlink control information for each of the at least one scheduled user device in the common search space candidates; and means for sending with the assigned short physical downlink control channel resources the fast downlink control information, wherein the fast downlink control information comprises an indication of the assigning of all scheduled users and an indication of a short physical downlink shared channel for the each of at least one scheduled user device scheduled in a downlink.

[0011] In accordance with the example embodiments as described in the paragraph above, at least the means for configuring, scheduling, assigning, and sending comprises a network interface, and computer program code stored on a computer-readable medium (e.g., when executed by at least one processor).

[0012] A further example embodiment is an apparatus comprising the apparatus of the previous paragraphs, wherein the common search space candidates are mutually non-overlapping, wherein the configuring comprises grouping the common search space candidates based on their aggregation level, wherein the grouping of the candidates comprises at least one of labelling and ordering the candidates within each group in a logical manner, wherein the assigning of the resources to carry the fast downlink control information in the common search space candidates occurs continuously in a logical manner within each aggregation level group, wherein the logical manner comprises starting from a common search space candidate with a lowest index, wherein the assigning contains an index of at least one of a last allocated common search space candidate and a first free common search space candidate within each aggregation level group, wherein the indication of the assigning contains a fixed amount of bits, wherein not all the common search space candidate groups are indicated by the fixed amount of bits, wherein the common search space candidate groups with a higher aggregation level are indicated with a higher priority, and/or wherein the short physical downlink shared channel is mapped to resources of the short physical control

channel candidates which are indicated as being unassigned and intersect with short physical downlink shared channel resource allocation.

[0013] In an example aspect of the invention, there is an apparatus, such as a remote user side apparatus, comprising: at least one processor; and at least one memory including computer program code, where the at least one memory and the computer program code are configured, with the at least one processor, to cause the apparatus to at least: receive a configuration of a short physical downlink control channel with common search space candidates; receive fast downlink control information on resources of the short physical downlink control channel carrying a downlink assignment, wherein the fast downlink control information comprises an indication of assigning of each of at least one scheduled user device in an downlink or uplink and an indication of an assigned short physical downlink shared channel; and based on the downlink assignment and the indication of assigned control resources, determine resources of the assigned short physical downlink shared channel.

[0014] In another example aspect of the invention, there is a method comprising: receiving a configuration of a short physical downlink control channel with common search space candidates; receiving fast downlink control information on resources of the short physical downlink control channel carrying a downlink assignment, wherein the fast downlink control information comprises an indication of assigning of each of at least one scheduled user device in an downlink or uplink and an indication of an assigned short physical downlink shared channel; and based on the downlink assignment and the indication of assigned control resources, determining resources of the assigned short physical downlink shared channel.

[0015] A further example embodiments is a method comprising the method of the previous paragraph, wherein the common search space candidates are mutually non-overlapping, wherein the configuring comprises grouping the common search space candidates based on an their aggregation level, wherein the grouping of the candidates comprises at least one of labelling and ordering the candidates within each group in a logical manner, wherein the indication of the assigning contains an index of at least one of a last allocated common search space candidate and a first free common search space

candidate within each aggregation level group, wherein the indication of the assigning contains a fixed amount of bits, wherein not all the common search space candidate groups are indicated by the fixed amount of bits, wherein the common search space candidate groups with higher aggregation level are indicated with a higher priority, wherein for determining the resource mapping it is assumed the short physical downlink data channel is mapped on short physical downlink control channel resource of candidates to be indicated as unassigned and intersects with resource allocation of short physical downlink data channel, and/or wherein the unassigned common search space candidates of an aggregation level group are all common search space candidates within the aggregation level group starting from the first free common search space candidate or after the last occupied common search space candidate within the aggregation level group.

[0016] A non-transitory computer-readable medium storing program code, the program code executed by at least one processor to perform the operations as at least described in the paragraphs above.

[0017] In still another example aspect of the invention, there is an apparatus comprising: means for receiving a configuration of a short physical downlink control channel with common search space candidates; means for receiving fast downlink control information on resources of the short physical downlink control channel carrying a downlink assignment, wherein the fast downlink control information comprises an indication of assigning of each of at least one_scheduled user device in an downlink or uplink and an indication of an assigned short physical downlink shared channel; and means based on the downlink assignment and the indication of assigned control resources, for determining resources of the assigned short physical downlink shared channel.

[0018] In accordance with the example embodiments as described in the paragraph above, at least the means for receiving, and determining comprises a network interface, and computer program code stored on a computer-readable medium (e.g., when executed by at least one processor.

[0019] A further example embodiments with an apparatus comprising the apparatus of the previous paragraphs, wherein the common search space candidates are mutually non-overlapping, wherein the configuring comprises grouping the common search space candidates based on an their aggregation level, wherein the grouping of the candidates comprises at least one of labelling and ordering the candidates within each group in a logical manner, wherein the indication of the assigning contains an index of at least one of a last allocated common search space candidate and a first free common search space candidate within each aggregation level group, wherein the indication of the assigning contains a fixed amount of bits, wherein not all the common search space candidate groups are indicated by the fixed amount of bits, wherein the common search space candidate groups with higher aggregation level are indicated with a higher priority, wherein for determining the resource mapping it is assumed the short physical downlink data channel is mapped on short physical downlink control channel resource of candidates to be indicated as unassigned and intersects with resource allocation of short physical downlink data channel, and/or wherein the unassigned common search space candidates of an aggregation level group are all common search space candidates within the aggregation level group starting from the first free common search space candidate or after the last occupied common search space candidate within the aggregation level group.

BRIEF DESCRIPTION OF THE DRAWINGS:

[0020] The foregoing and other aspects of embodiments of this invention are made more evident in the following Detailed Description, when read in conjunction with the attached Drawing Figures, wherein:

[0021] Figure 1 shows two step control operation of a downlink subframe;

[0022] Figure 2 shows a simplified block diagram of a system in which exemplary embodiments of this invention may be practiced;

[0023] Figures 3a, 3b, and 3c shows different scenarios with resources reserved by an eNB in PDCCH in sTTI; and

[0024] Figures 4A and 4B each show a method in accordance with example embodiments of the invention which may be performed by an apparatus.

DETAILED DESCRIPTION:

[0025] In this invention, teachings in accordance with the example embodiments of this invention relate generally to reusing reserved unused control resources for data transmissions, reducing control overhead and providing an efficient signaling mechanism of unused resources to every scheduled UE. This signaling and method in accordance with the example embodiments of the invention uses significantly less bits than a bitmap, and is able to signal majority of free control resources.

[0026] The example embodiments of the invention relate to LTE-Advanced Pro system, which will be part of 3GPP LTE Rel-14/15. More specifically, the example embodiments relate to latency reduction for 3GPP LTE. Both FDD and TDD duplex modes are considered.

[0027] During RAN1 meeting #84bis in Busan, control channel design for latency reduction has been discussed. It has been noted under possible agreements in chairman's meeting minutes that "sPDSCH assigned by a sPDCCH can be allocated to unused REs within the sPDCCH region if sPDCCH region is not shared with PDCCH region". The example embodiments of the invention as disclosed herein provide a solution on how to reuse unused resources of sPDCCH for sPDSCH.

[0028] When a UE is scheduled using self-contained sPDCCH, i.e. sPDCCH is part of UEs sPDSCH allocation, the UE automatically knows which resources are unused. For example, when a UE finds a DL grant with given aggregation-level (AL), it knows that all other resources of sPDCCH contain sPDSCH symbols of that UE scheduled in that resource. However, this operation comes with several disadvantages. UE scheduled with self-contain grant: 1) cannot change flexibly its allocation on sTTI

bases or needs to search over all subband potentially containing control resources, and 2) uplink grants cannot be transmitted in self-contained manner.

[0029] Example embodiments of the invention work to address at least these disadvantages.

[0030] It is noted that currently there is more than one type of Data Transmission Scheduling Scheme in LTE. In such a scheduling scheme, the PDCCH carries scheduling assignments and other control region information in the form of DCI messages. A PDCCH is transmitted on one control channel element (CCE) or an aggregation of several consecutive CCEs.

[0031] The DCI format is generated and channel coded according to the required DCI and PDCCH format, PDCCH scrambling, modulation, precoding and layer mapping are performed to form complex symbols. These complex symbols are mapped onto resource elements (REs) of a control region. The REs may be defined in terms of CCEs allocated to a transmission, and the number of CCEs allocated is given by the PDCCH format. The control region of a subframe is a collection of CCEs and can contain PDCCHs for multiple UEs thus the UE has to monitor this area to extract its own control information. The receiver (e.g., UE) decodes the information to determine if an UL Grant is allowed, and if so transmit the uplink data through a PUSCH. Moreover, the receiver (e.g., UE) decodes the information to determine if a DL assignment is present, and if so decodes the downlink data transmitted through a PDSCH.

[0032] If a UE is only informed of the number of symbols within a control region of a subframe and is not provided with the location of its corresponding PDCCH, then the UE finds its PDCCH by monitoring a set of PDCCH candidates in every subframe. This is referred to as blind decoding. The UE unmasks each control candidate's CRC using its Radio Network Temporary Identifier (RNTI). If no CRC error is detected, the UE considers it as a successful decoding attempt and reads the control information within the successful candidate.

[0033] A common search space in LTE carries common control information and is monitored by all UEs in a cell. The number of CCE aggregation levels supported by the common search space is limited to two (e.g., 4 and 8) as compared to the UE-specific search space where four CCE aggregation levels on PDCCH and up to five CCE aggregation levels on EPDCCH are possible. The common control space is used to carry important initial information including paging information, system information and random access procedures. When searching the common control space the decoder always starts decoding from the first CCE. The decoding is done on every possible PDCCH candidate set for given PDCCH format until it successfully decodes the PDCCH present in common search space.

[0034] The example embodiments of the invention work to at least configure a common search space in sPDCCH for all sTTI UEs, and at the same time decrease the total number of search space candidates for resource allocations.

[0035] As shown in Figure 1 there is a downlink (DL) subframe 10. In Figure 1 there is shown a two-stage control operation. An Example embodiment of the invention builds on top of two-stage control operation illustrated in Figure 1. In Figure 1: There is a Step 1: which includes a slow DCI 20 shown in upper left corner "sTTI band grant 7 symbol," and a step 2: which includes a fast DCI 30 shown as "7 sym sPDCCH."

[0036] The eNB broadcasts sTTI band presence in slow DCI (1ms granularity) to all sTTI UEs on legacy PDCCH and fast DCI on sPDCCH assigns resources to multiple sTTI UEs within the sTTI band. The slow-DCI contains resource allocation of sTTI band as well contains information on size of search space of the sPDCCH. For example, signalling the number of candidates for each AL can define the size of sPDCCH search space. As a consequence, all UEs listening to slow-DCI are aware of all configured control resources of sPDCCH in a subframe.

[0037] An example embodiment of the invention relates to designing a single common search space for fast UL and DL grants for several UEs. The example embodiments of the invention have at least the following advantages:

1) DL assignment and UL grants can be multiplexed within the same search space using fast DCIs, which can use a same DCI format. This resulting into decreased number of blind searches;
2) The fast DCIs can be transmitted with different aggregation levels.
3) Blockage between DCI candidates of different ALs is removed and design allows for configuration (on subframe bases) of less candidates and therefore reduced total search space.
4) Allows for simple low overhead signalling of allocated DCI candidates within the common search space, enabling reuse of unused control resource for short PDSCH.
5) Compared to self-contained DCI, short PDSCH can be scheduled on arbitrary resource within the short TTI band.

[0038] Before describing the example embodiments of the invention in details, reference is made to Figure 2 for illustrating a simplified block diagram of various electronic devices that are suitable for use in practicing the example embodiments of this invention. In Figure 2 a wireless access is adapted for communication between a user equipment UE 10 and a network node NN 12 or other access node of an access network 9. In accordance with the example embodiments the NN 12 can be any network device e.g., a base station or other device that is part of or separate from the network. The network 9 may include or may use a higher controlling node (not shown, by non-limiting example a gateway GW, a user plane entity UPE, a mobility management entity MME, or a system architecture evolution gateway SAE-GW) for operations in accordance with the example embodiments. Such a higher controlling node may be accessible via any communication link, including the antenna 10E and/or 12E, and/or via Internet 14.

[0039] The UE 10 includes a data processor (DP) 10A, a memory (MEM) 10B that stores a program (PROG) 10C, and a suitable radio frequency (RF) transmitter and receiver 10D coupled to one or more antennas 10E for bidirectional wireless communications over a data link 11 with the NN 12. The NN 12 also includes a DP 12A, a MEM 12B that stores a PROG 12C, and a suitable RF transmitter and receiver

12D coupled to one or more antennas 12E. The NN 12 may be coupled via a data link 13 to the internet or other broader communication network. Also at the UE 10 and the NN 12 there are resource processors 10F, 12F, respectively, for defining and configuring resource allocation of sTTI band resources and search space information in accordance with the example embodiments of the invention as described herein. At least one of the PROGs 10C and 12C is assumed to include program instructions that, when executed by the associated DP, enable the electronic device to operate in accordance with the example embodiments of this invention as described in detail below.

[0040] In general, the example embodiments of this invention may be implemented by computer software executable by the DP 10A of the UE 10 and by the DP12A of the NN 12, or other DPs, or by hardware, or by a combination of software and/or firmware and hardware. The interactions between the major logical elements should be obvious to those skilled in the art for the level of detail needed to gain an understanding of the broader aspects of the invention beyond only the specific examples herein. It should be noted that the invention may be implemented with an application specific integrated circuit ASIC, a field programmable gated array FPGA, a digital signal processor or other suitable processor to carry out the intended function of the invention, including a central processor, a random access memory RAM, read only memory ROM, and communication ports for communicating between the NN 12 and the UE 10 as detailed above.

[0041] Further, it is noted that the various embodiments of the UE 10 can include, but are not limited to, cellular telephones, personal digital assistants (PDAs) having wireless communication capabilities, portable computers having wireless communication capabilities, image capture devices such as digital cameras having wireless communication capabilities, gaming devices having wireless communication capabilities, music storage and playback appliances having wireless communication capabilities, Internet appliances permitting wireless Internet access and browsing, as well as portable units or terminals that incorporate combinations of such functions.

[0042] The MEMs 10B and 12B may be of any type suitable to the local technical environment and may be implemented using any suitable data storage technology, such as semiconductor based memory devices, magnetic memory devices and systems, optical memory devices and systems, transitory memory, non-transitory memory, fixed memory and removable memory. The DPs 10A and 12A may be of any type suitable to the local technical environment, and may include one or more of general purpose computers, special purpose computers, microprocessors, digital signal processors (DSPs) and processors based on a multi-core processor architecture, as non-limiting examples.

[0043] At least one of the memories is assumed to tangibly embody software program instructions that, when executed by the associated processor, enable the electronic device to operate in accordance with the example embodiments of this invention, as detailed by example above. As such, the example embodiments of this invention may be implemented at least in part by computer software executable by the controller/DP of the UE 10 or the NN 12 by hardware, or by a combination of software and hardware.

[0044] As similarly stated above, the example embodiments of the invention build on top of two-stage control operation as illustrated in Figure 1. The example embodiments of the invention provide a novel method and apparatus to at least:

1. Configure (e.g., DP 12A and/or processor 12F and PROG 12C as in Figure 2), by a device, such as a base station (e.g., the NN 12 as in Figure 2), a common search space in sPDCCH for all sTTI UEs, as illustrated in Figure 3A as described below. Short PDCCH search space candidates are non-overlapping and common to all UEs;

2. Group configured candidates by AL and order/label candidates logically within each AL group. An example of grouping is shown in Figure 3B.

3. Allocate (e.g., DP 12A and/or processor 12F and PROG 12C as in Figure 2) DCIs in each AL candidate group continuously (in logical manner), for

example from left to right as shown in Figure 3C as described below or in increasing logical order starting from the candidate with the lowest logical index; and

4. Signal (antenna 12E and transceiver 12D as in Figure 2) in each scheduled UE's DCI, carrying the DL assignment, the number of free/allocated candidates in each AL candidate group, for example the index of the last allocated common search space candidate or the first free common search space candidate within each aggregation level group, given a total number of signalling bits, the device (e.g., an eNB) can assign bits (e.g., DP 12A and/or processor 12F and PROG 12C as in Figure 2) so that free/allocated candidates from AL groups with higher number of CCEs are signalled first.

[0045] Figure 3A shows an example of a configured set of candidate resources of sPDCCH used in a particular sTTI which shows 9 candidates. The sPDCCH consists of 18 control channel elements (CCE). The resources of these candidates are non-overlapping and are known/common to all UEs. In this case, all receiving devices (e.g., UEs) perform 9 blind decodes on the common search space candidates of the sPDCCH, if a single DCI format per receiving device is configured. This example with 9 blind decodes (4xAL1+3xAL2+2xAL4) can guarantee scheduling 4 simultaneous DCIs with 99% probability, assuming 43bit DCI and macro geometry. Furthermore, reducing the common SS to total 5 candidates (2xAL1+2xAL2+1xAL4), can schedule 4 DCIs in macro geometry with probability 95%.

[0046] Figure 3B shows an example of sorting the candidates into groups according to their aggregation level, forming three aggregation level groups and ordering/labelling them with a number in logical order within each aggregation level group. All candidates within a group are part of UEs search space. However, not all the groups are necessarily part of a UEs search space. This grouping in accordance with the example embodiments allows that a UE (e.g., the UE 10 as in Figure 2) is configured (e.g., NN 12 as in Figure 2) to only follow for example only two AL groups at the time. This means that UE does not need to follow all the candidates in the search space, and this signaling framework can work as it is.

[0047] Figure 3C shows assigned resources (shaded) in sPDCCH in a particular sTTI. Figure 3C shows resources as shown in Figure 3A which are shaded to show DCIs in accordance with the example embodiments of the invention that are assigned on CCEs for these resources. Here, a device (e.g., an eNB) signals in every DL assignment DCI the assigned (or alternatively unassigned) short physical downlink control channel candidate with a fixed number of bits (e.g. 4bits), where first two bits correspond to assigned/unassigned resources in AL group 3, and the other two bits to the assigned/unassigned free resources in AL group 2. The number of bits needed to signal a number of assigned/unassigned resources can be determined as log2(N+1), where N is an integer indicating the total number of candidates within an AL group. In this example, eNB signals indication of the unassigned resources of the short physical downlink control channel as "01 10", because one unassigned resource is available in AL group 3 and 2 resources in AL group 2. Furthermore, 2 CCE of AL1 stayed unused for data because they are not signalled to a UE, however this is only 11% (2 out of18 possible control channel elements) of total allocated control resources. In addition, if 7 bits in DCI would be available, then all three groups could have been signalled. Furthermore, if 5 bits would be available, the number of unassigned resources within AL group 1 could be still signalled with a single bit only, saying last candidate assigned or unassigned. This resulting in to partial signalling of an AL group.

[0048] In addition, if a UE detects own DL assignment on certain position and certain AL group it can then be seen that all control resources on the left or in increasing logical order in that AL are occupied, and the amount of required bits for signalling in that AL for this UE can be smaller. This means that signaling to a UE can be user-specific.

[0049] An advantage of this approach is that only a modest number of bits is required compared to signalling of a bitmap of free BD candidates while eNB can signal dynamically the majority of unused resources to the scheduled UEs in DL. The eNB can than place short PDSCH of a UE to unused control resources which were signalled to the UE as unused/unassigned.

[0050] Figure 4A illustrates operations which may be performed by a network device such as, but not limited to, a network node NN 12 as in Figure 2. As shown in step 400 there is configuring a short physical downlink control channel with common search space candidates for at least one user device; as shown in step 410 there is scheduling the at least one user device in a downlink or uplink; at step 420 assigning resources of the short physical downlink control channel to carry fast downlink control information for each of the at least one scheduled user device in the common search space candidates, and at step 430 sending with the assigned short physical downlink control channel resources the fast downlink control information, wherein the fast downlink control information comprises an indication of the assigning of all scheduled users and an indication of a short physical downlink shared channel for the each of at least one scheduled user device scheduled in a downlink.

[0051] In accordance with the example embodiments as described in the paragraph above, the common search space candidates are mutually non-overlapping.

[0052] In accordance with the example embodiments as described in the paragraphs above, the configuring comprises grouping the common search space candidates based on their aggregation level.

[0053] In accordance with the example embodiments as described in the paragraphs above, the grouping of the candidates comprises at least one of labelling and ordering the candidates within each group in a logical manner e.g., ordered manner.

[0054] In accordance with the example embodiments as described in the paragraphs above, the assigning of the resources to carry the fast downlink control information in the common search space candidates occurs continuously in a logical manner within each aggregation level group, wherein the logical manner comprises starting from a common search space candidate with a lowest index.

[0055] In accordance with the example embodiments as described in the paragraphs above, the assigning contains an index of at least one of a last allocated

common search space candidate and a first free common search space candidate within each aggregation level group.

[0056] In accordance with the example embodiments as described in the paragraphs above, the indication of the assigning contains a fixed amount of bits.

In accordance with the example embodiments as described in the paragraphs above, not all the common search space candidate groups are indicated by the fixed amount of bits.

[0057] In accordance with the example embodiments as described in the paragraphs above, common search space candidate groups with a higher aggregation level are indicated with a higher priority.

[0058] In accordance with the example embodiments as described in the paragraphs above, the short physical downlink shared channel is mapped to resources of the short physical control channel candidates which are indicated as being unassigned and intersect with short physical downlink shared channel resource allocation.

[0059] A non-transitory computer-readable medium (MEM 12B and/or 10B of Figure 2) storing program code (PROG 12C and/or 10C of Figure 2), the program code executed by at least one processor (DP 12A and/or DP 12F; and/or DP 10A and/or 10F of Figure 2) to perform the operations as at least described in the paragraphs above.

[0060] In yet another example aspect of the invention, there is an apparatus comprising: means for configuring a short physical downlink control channel with common search space candidates for at least one user device; means for scheduling the at least one user device in a downlink or uplink; means for assigning resources of the short physical downlink control channel to carry fast downlink control information for each of the at least one scheduled user device in the common search space candidates; and means for sending with the assigned short physical downlink control channel resources the fast downlink control information, wherein the fast downlink control

information comprises an indication of the assigning of all scheduled users and an indication of a short physical downlink shared channel for the each of at least one scheduled user device scheduled in a downlink.

[0061] In accordance with the example embodiments as described in the paragraph above, at least the means for configuring, scheduling, assigning, and sending comprises a network interface, and computer program code stored on a computer-readable medium (e.g., when executed by at least one processor).

[0062] Figure 4B illustrates operations which may be performed by a device such as, but not limited to, a device (e.g., the UE 10 as in Figure 2). As shown in step 450 of Figure 4B, there is receiving a configuration of a short physical downlink control channel with common search space candidates; as shown in step 460 there is receiving fast downlink control information on resources of the short physical downlink control channel carrying a downlink assignment, wherein the fast downlink control information comprises an indication of assigning of each of at least one scheduled user device in an downlink or uplink and an indication of an assigned short physical downlink shared channel; and as shown in step 470 there is, based on the downlink assignment and the indication of assigned control resources, determining resources of the assigned short physical downlink shared channel.

[0063] In accordance with the example embodiments as described in the paragraph above, the common search space candidates are mutually non-overlapping.

[0064] In accordance with the example embodiments as described in the paragraphs above, the configuring comprises grouping the common search space candidates based on an their aggregation level.

[0065] In accordance with the example embodiments as described in the paragraphs above, the grouping of the candidates comprises at least one of labelling and ordering the candidates within each group in a logical manner.

[0066] In accordance with the example embodiments as described in the paragraphs above, the indication of the assigning contains an index of at least one of a last allocated common search space candidate and a first free common search space candidate within each aggregation level group.

[0067] In accordance with the example embodiments as described in the paragraphs above, the indication of the assigning contains a fixed amount of bits.

[0068] In accordance with the example embodiments as described in the paragraphs above, not all the common search space candidate groups are indicated by the fixed amount of bits.

[0069] In accordance with the example embodiments as described in the paragraphs above, common search space candidate groups with higher aggregation level are indicated with a higher priority.

[0070] In accordance with the example embodiments as described in the paragraphs above, in determining the resource mapping it is assumed the short physical downlink data channel is mapped on short physical downlink control channel resource of candidates to be indicated as unassigned and intersects with resource allocation of short physical downlink data channel.

[0071] In accordance with the example embodiments as described in the paragraphs above, unassigned common search space candidates of an aggregation level group are all common search space candidates within the aggregation level group starting from the first free common search space candidate or after the last occupied common search space candidate within the aggregation level group.

[0072] A communication system comprising the apparatus in accordance with any one of the features related to Figures 4A and 4B as in the paragraphs above.

[0073] A non-transitory computer-readable medium (MEM 12B and/or 10B of Figure 2) storing program code (PROG 12C and/or 10C of Figure 2), the program code

executed by at least one processor (DP 12A and/or DP 12F; and/or DP 10A and/or 10F of Figure 2) to perform the operations as at least described in the paragraphs above.

[0074] In accordance with an example embodiment of the invention, there is an apparatus (such as the NN 12 and/or UE 10 of Figure 2) comprising: means for configuring (DP 12A and/or 10A, DP 12F and/or 10F, PROG 12C and/or 10C, and MEM 12B and/or 10B of Figure 2) a short physical downlink control channel with common search space candidates for at least one user device, means for scheduling the at least one user device in a downlink or uplink; means for assigning (DP 12A and/or 10A, DP 12F and/or 10F, PROG 12C and/or 10C, and MEM 12B and/or 10B of Figure 2) resources of the short physical downlink control channel to carry fast downlink control information for each of the at least one scheduled user device in the common search space candidates; and means for sending (DP 12A and/or 10A, DP 12F and/or 10F, PROG 12C and/or 10C, and MEM 12B and/or 10B of Figure 2) with the assigned short physical downlink control channel resources the fast downlink control information, wherein the fast downlink control information comprises an indication of the assigning of all scheduled users and an indication of a short physical downlink shared channel for the each of at least one scheduled user device scheduled in a downlink;

[0075] In still another example aspect of the invention, there is an apparatus comprising: means for receiving a configuration of a short physical downlink control channel with common search space candidates; means for receiving fast downlink control information on resources of the short physical downlink control channel carrying a downlink assignment, wherein the fast downlink control information comprises an indication of assigning of each of at least one scheduled user device in an downlink or uplink and an indication of an assigned short physical downlink shared channel; and means based on the downlink assignment and the indication of assigned control resources, for determining resources of the assigned short physical downlink shared channel.

[0076] In accordance with the example embodiments as described in the paragraph above, at least the means for receiving, and determining comprises a network

interface, and computer program code stored on a computer-readable medium (e.g., when executed by at least one processor.

[0077] Any of the embodiments of this invention as described herein may be implemented by computer software executable by a data processor of a device such as the NN 12 and/or UE 10 of Figure 2 The operations in accordance with the example may be implemented with such as the DP 12A and/or 10A, DP 12F and/or 10F, PROG 12C and/or 10C, and MEM 12B and/or 10B of Figure 2, or by hardware circuitry, or by a combination of software and hardware circuitry. Further in this regard it should be noted that the various blocks of the logic flow diagram of Figures 4A and 4B may represent program steps, or interconnected logic circuits, blocks and functions, or a combination of program steps and logic circuits, blocks and functions for performing the specified tasks.

[0078] In general, the various embodiments of a device in accordance with the example embodiments [e.g., NN 12 and/or UE 10 of Figure 2.] can include, but are not limited to, cellular telephones, personal digital assistants (PDAs) having wireless communication capabilities, portable computers having wireless communication capabilities, image capture devices such as digital cameras having wireless communication capabilities, gaming devices having wireless communication capabilities, music storage and playback appliances having wireless communication capabilities, Internet appliances permitting wireless Internet access and browsing, as well as portable units or terminals that incorporate combinations of such functions.

[0079] The embodiments of this invention may be implemented by computer software executable by a data processor of a mobile device and/or network device e.g., the user equipment 10 (UE 10) and/or Network Node 12 (NN 12) as shown in Figure 2, such as the processors 10A and/or 10F or 12A and/or 12F as shown in Figure 2, or by hardware, or by a combination of software and hardware. Further in this regard it should be noted that the various blocks of the logic flow diagram of Fig(s) 4A and 4B may represent program steps, or interconnected logic circuits, blocks and functions, or a combination of program steps and logic circuits, blocks and functions. It is noted that any of these devices may have multiple processors (e.g. RF, baseband, imaging, user

interface) which operate in a slave relation to a master processor. The teachings may be implemented in any single one or combination of those multiple processors.

[0080] The memory [or memories] such as memories 10B and/or 12B as shown in Figure 2 may be of any type suitable to the local technical environment and may be implemented using any suitable data storage technology, such as semiconductor-based memory devices, magnetic memory devices and systems, optical memory devices and systems, transitory memory, non-transitory memory, fixed memory and removable memory. The processors 10A and/or 10F or 12A and/or 12F as shown in Figure 2 may be of any type suitable to the local technical environment, and may include one or more of general purpose computers, special purpose computers, microprocessors, digital signal processors (DSPs) and processors based on a multi-core processor architecture, as non-limiting examples.

[0081] It is noted that any reference to a user equipment (UE) and/or base station (eNB) and/or other particular device performing an operation in accordance with the example embodiments is non-limiting. Any of the operations in accordance with the example embodiments of the invention may be performed by any suitable device or apparatus, and these suitable device or apparatus does not need to be a UE or eNB or other device as described.

[0082] In general, the various embodiments may be implemented in hardware or special purpose circuits, software, logic or any combination thereof. For example, some aspects may be implemented in hardware, while other aspects may be implemented in firmware or software which may be executed by a controller, microprocessor or other computing device, although the invention is not limited thereto. While various aspects of the invention may be illustrated and described as block diagrams, flow charts, or using some other pictorial representation, it is well understood that these blocks, apparatus, systems, techniques or methods described herein may be implemented in, as non-limiting examples, hardware, software, firmware, special purpose circuits or logic, general purpose hardware or controller or other computing devices, or some combination thereof.

[0083] Embodiments of the inventions may be practiced in various components such as integrated circuit modules. The design of integrated circuits is by and large a highly automated process. Complex and powerful software tools are available for converting a logic level design into a semiconductor circuit design ready to be etched and formed on a semiconductor substrate.

[0084] The word "exemplary" as may be used herein means "serving as an example, instance, or illustration." Any embodiment described herein as "exemplary" is not necessarily to be construed as preferred or advantageous over other embodiments. All of the embodiments described in this Detailed Description are exemplary embodiments provided to enable persons skilled in the art to make or use the invention and not to limit the scope of the invention which is defined by the claims.

[0085] The foregoing description has provided by way of exemplary and non-limiting examples a full and informative description of the best method and apparatus presently contemplated by the inventors for carrying out the invention. However, various modifications and adaptations may become apparent to those skilled in the relevant arts in view of the foregoing description, when read in conjunction with the accompanying drawings and the appended claims. However, all such and similar modifications of the teachings of this invention will still fall within the scope of this invention.

[0086] It should be noted that the terms "connected," "coupled," or any variant thereof, mean any connection or coupling, either direct or indirect, between two or more elements, and may encompass the presence of one or more intermediate elements between two elements that are "connected" or "coupled" together. The coupling or connection between the elements can be physical, logical, or a combination thereof. As employed herein two elements may be considered to be "connected" or "coupled" together by the use of one or more wires, cables and/or printed electrical connections, as well as by the use of electromagnetic energy, such as electromagnetic energy having wavelengths in the radio frequency region, the microwave region and the optical (both visible and invisible) region, as several non-limiting and non-exhaustive examples.

[0087] Furthermore, some of the features of the preferred embodiments of this invention could be used to advantage without the corresponding use of other features. As such, the foregoing description should be considered as merely illustrative of the principles of the invention, and not in limitation thereof.

CLAIMS

What is claimed is:

1. A method, comprising:

configuring a short physical downlink control channel with common search space candidates for at least one user device;

scheduling the at least one user device in a downlink or uplink;

assigning resources of the short physical downlink control channel to carry fast downlink control information for each of the at least one scheduled user device in the common search space candidates; and

sending with the assigned short physical downlink control channel resources the fast downlink control information, wherein the fast downlink control information comprises an indication of the assigning of all scheduled users and an indication of a short physical downlink shared channel for the each of at least one scheduled user device scheduled in a downlink.

2. The method of claim 1, wherein the common search space candidates are mutually non-overlapping.

3. The method of claim 1, wherein the configuring comprises grouping the common search space candidates based on their aggregation level.

4. The method of claim 3, wherein the grouping of the candidates comprises at least one of labelling and ordering the candidates within each group in a logical manner.

5. The method of any one of claims 1, 2, 3, and 4, wherein the assigning of the resources to carry the fast downlink control information in the common search space candidates occurs continuously in a logical manner within each aggregation level group, wherein the logical manner comprises starting from a common search space candidate with a lowest index.

6. The method of claim 5, wherein indication of the assigning contains an index of at least one of a last allocated common search space candidate and a first free common search space candidate within each aggregation level group.

7. The method of claim 1, wherein the indication of the assigning contains a fixed amount of bits.

8. The method of claim 3, 4 and 7, wherein not all the common search space candidate groups are indicated by the fixed amount of bits.

9. The method of any one of claims 3, 4, and 7, wherein common search space candidate groups with a higher aggregation level are indicated with a higher priority.

10. The method of claim1, where the short physical downlink shared channel is mapped to resources of the short physical control channel candidates which are indicated as being unassigned and intersect with short physical downlink shared channel resource allocation.

11. A non-transitory computer-readable medium storing program code, the program code when executed by at least one processor to perform the method of any of claims 1-10.

12. An apparatus comprising:

at least one processor; and

at least one memory including computer program code, where the at least one memory and the computer program code are configured, with the at least one processor, to cause the apparatus to at least:

configure a short physical downlink control channel with common search space candidates for at least one user device;

schedule the at least one user device in a downlink or uplink;

assign resources of the short physical downlink control channel to carry fast downlink control information for each of the at least one scheduled user device in the common search space candidates; and

send with the assigned short physical downlink control channel resources the fast downlink control information, wherein the fast downlink control information comprises an indication of the assigning of all scheduled users and an indication of a short physical downlink shared channel for the each of at least one scheduled user device scheduled in a downlink.

13. The apparatus of claim 12, wherein the common search space candidates are mutually non-overlapping.

14. The apparatus of claim 12, wherein the configuring comprises grouping the common search space candidates based on their aggregation level.

15. The apparatus of claim 14, wherein the grouping of the candidates comprises at least one of labelling and ordering the candidates within each group in a logical manner.

16. The apparatus of any one of claims 12 to 15, wherein the assigning of the resources to carry the fast downlink control information in the common search space candidates occurs continuously in a logical manner within each aggregation level group, wherein the logical manner comprises starting from a common search space candidate with a lowest index.

17. The apparatus of claim 16, wherein indication of the assigning contains an index of at least one of a last allocated common search space candidate and a first free common search space candidate within each aggregation level group.

18. The apparatus of claim 12, wherein the indication of the assigning contains a fixed amount of bits.

19. The apparatus of claim 18, wherein not all the common search space candidate groups are indicated by the fixed amount of bits.

20. The apparatus of any one of claims 18 and 19, wherein common search space candidate groups with a higher aggregation level are indicated with a higher priority.

21. The apparatus of claim12, where the short physical downlink shared channel is mapped to resources of the short physical control channel candidates which are indicated as being unassigned and intersect with short physical downlink shared channel resource allocation.

22. An apparatus comprising:

means for configuring a short physical downlink control channel with common search space candidates for at least one user device;

means for scheduling the at least one user device in a downlink or uplink;

means for assigning resources of the short physical downlink control channel to carry fast downlink control information for each of the at least one scheduled user device in the common search space candidates; and

means for sending with the assigned short physical downlink control channel resources the fast downlink control information, wherein the fast downlink control information comprises an indication of the assigning of all scheduled users and an indication of a short physical downlink shared channel for the each of at least one scheduled user device scheduled in a downlink.

23. The apparatus of claim 22, wherein the common search space candidates are mutually non-overlapping.

24. The apparatus of claim 22, wherein the configuring comprises grouping the common search space candidates based on their aggregation level.

25. The apparatus of claim 24, wherein the grouping of the candidates comprises at least one of labelling and ordering the candidates within each group in a logical manner.

26. The apparatus of any one of claims 22 to 25, wherein the assigning of the resources to carry the fast downlink control information in the common search space candidates occurs continuously in a logical manner within each aggregation level group, wherein the logical manner comprises starting from a common search space candidate with a lowest index.

27. The apparatus of claim 26, wherein indication of the assigning contains an index of at least one of a last allocated common search space candidate and a first free common search space candidate within each aggregation level group.

28. The aparatus of claim 22, wherein the indication of the assigning contains a fixed amount of bits.

29. The apparatus of claim 28, wherein not all the common search space candidate groups are indicated by the fixed amount of bits.

30. The apparatus of claim 24, wherein common search space candidate groups with a higher aggregation level are indicated with a higher priority.

31. The apparatus of claim 22, where the short physical downlink shared channel is mapped to resources of the short physical control channel candidates which are indicated as being unassigned and intersect with short physical downlink shared channel resource allocation.

32. A method, comprising:

receiving a configuration of a short physical downlink control channel with common search space candidates;

receiving fast downlink control information on resources of the short physical downlink control channel carrying a downlink assignment, wherein the fast downlink control information comprises an indication of assigning of each of at least one scheduled user device in an downlink or uplink and an indication of an assigned short physical downlink shared channel; and

based on the downlink assignment and the indication of assigned control resources, determining resources of the assigned short physical downlink shared channel.

33. The method of claim 32, wherein the common search space candidates are mutually non-overlapping.

34. The method of claim 32, wherein the configuring comprises grouping the common search space candidates based on their aggregation level.

35. The method of claim 34, wherein the grouping of the candidates comprises at least one of labelling and ordering the candidates within each group in a logical manner.

36. The method of claim 32, wherein the indication of the assigning contains an index of at least one of a last allocated common search space candidate and a first free common search space candidate within each aggregation level group.

37. The method of claim 32, wherein the indication of the assigning contains a fixed amount of bits.

38. The method of any one of claims 34, 35, and 37, wherein not all the common search space candidate groups are indicated by the fixed amount of bits.

39. The method of any one of claims 34 and 37, wherein common search space candidate groups with higher aggregation level are indicated with a higher priority.

40. The method of claim 32, where in determining the resource mapping it is assumed the short physical downlink data channel is mapped on short physical downlink control channel resource of candidates to be indicated as unassigned and intersects with resource allocation of short physical downlink data channel.

41. The method of claim 40, where unassigned common search space candidates

of an aggregation level group are all common search space candidates within the aggregation level group starting from the first free common search space candidate or after the last occupied common search space candidate within the aggregation level group.

42. A non-transitory computer-readable medium storing program code, the program code when executed by at least one processor to perform the method of any of claims 32-41.

43. An apparatus, comprising:

at least one processor; and

at least one memory including computer program code, where the at least one memory and the computer program code are configured, with the at least one processor, to cause the apparatus to at least:

receive a configuration of a short physical downlink control channel with common search space candidates;

receive fast downlink control information on resources of the short physical downlink control channel carrying a downlink assignment, wherein the fast downlink control information comprises an indication of assigning of each of at least one scheduled user device in an downlink or uplink and an indication of an assigned short physical downlink shared channel; and

based on the downlink assignment and the indication of assigned control resources, determine resources of the assigned short physical downlink shared channel.

44. The apparatus of claim 43, wherein the common search space candidates are mutually non-overlapping.

45. The apparatus of claim 43, wherein the configuring comprises grouping the common search space candidates based on their aggregation level.

46. The apparatus of claim 45, wherein the grouping of the candidates comprises at least one of labelling and ordering the candidates within each group in a logical

manner.

47. The apparatus of claim 43, wherein the indication of the assigning contains an index of at least one of a last allocated common search space candidate and a first free common search space candidate within each aggregation level group.

48. The apparatus of claim 43, wherein the indication of the assigning contains a fixed amount of bits.

49. The method of claim 48, wherein not all the common search space candidate groups are indicated by the fixed amount of bits.

50. The apparatus of claim 45, wherein common search space candidate groups with higher aggregation level are indicated with a higher priority.

51. The apparatus of claim 43, where in determining the resource mapping it is assumed the short physical downlink data channel is mapped on short physical downlink control channel resource of candidates to be indicated as unassigned and intersects with resource allocation of short physical downlink data channel.

52. The apparatus of claim 51, where unassigned common search space candidates of an aggregation level group are all common search space candidates within the aggregation level group starting from the first free common search space candidate or after the last occupied common search space candidate within the aggregation level group.

53. An apparatus, comprising:

means for receiving a configuration of a short physical downlink control channel with common search space candidates;

means for receiving fast downlink control information on resources of the short physical downlink control channel carrying a downlink assignment, wherein the fast downlink control information comprises an indication of assigning of each of at

least one scheduled user device in an downlink or uplink and an indication of an assigned short physical downlink shared channel; and

means, based on the downlink assignment and the indication of assigned control resources, for determining resources of the assigned short physical downlink shared channel.

54. The apparatus of claim 53, wherein the common search space candidates are mutually non-overlapping.

55. The apparatus of claim 53, wherein the configuring comprises grouping the common search space candidates based on their aggregation level.

56. The apparatus of claim 55, wherein the grouping of the candidates comprises at least one of labelling and ordering the candidates within each group in a logical manner.

57. The apparatus of claim 53, wherein the indication of the assigning contains an index of at least one of a last allocated common search space candidate and a first free common search space candidate within each aggregation level group.

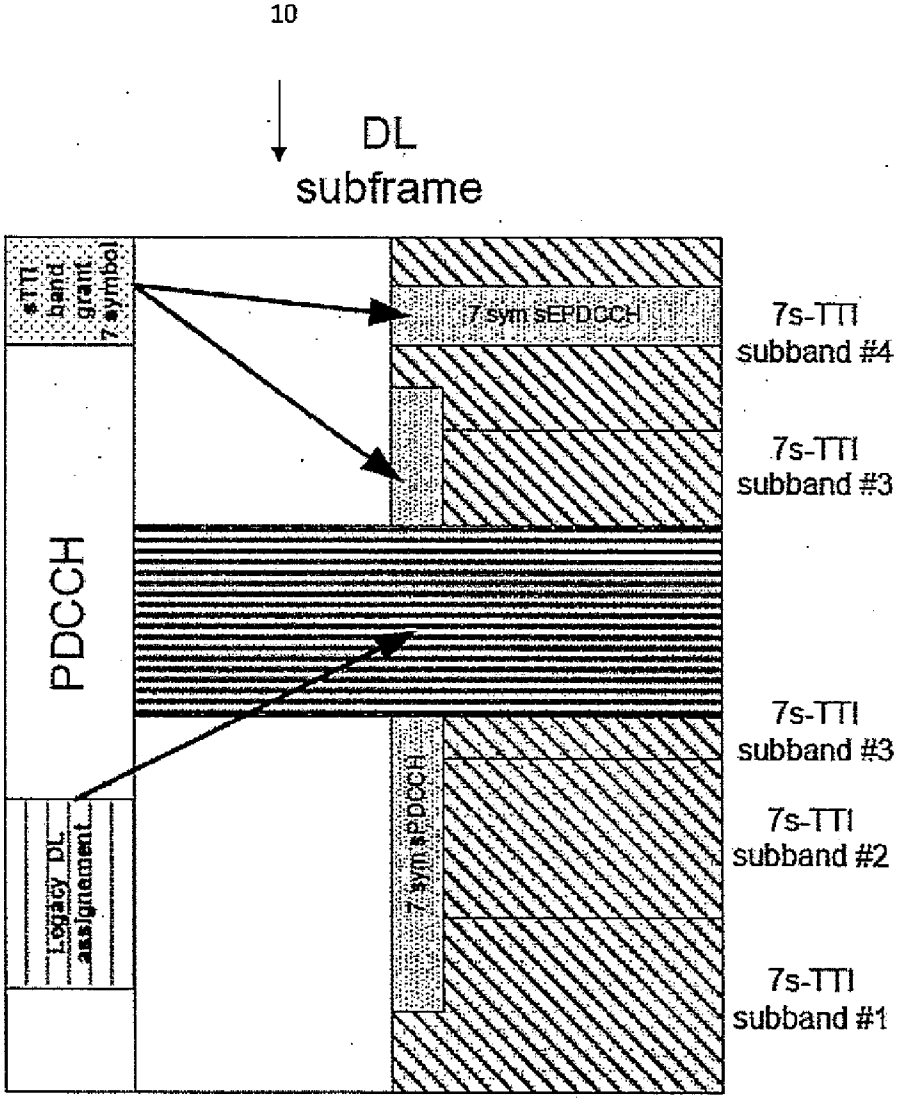
58. The apparatus of claim 53, wherein the indication of the assigning contains a fixed amount of bits.

59. The apparatus of claim 58, wherein not all the common search space candidate groups are indicated by the fixed amount of bits.

60. The apparatus of claim 55, wherein common search space candidate groups with higher aggregation level are indicated with a higher priority.

61. The apparatus of claim 53, where in determining the resource mapping it is assumed the short physical downlink data channel is mapped on short physical downlink control channel resource of candidates to be indicated as unassigned and intersects with resource allocation of short physical downlink data channel.

62. The apparatus of claim 61, where unassigned common search space candidates of an aggregation level group are all common search space candidates within the aggregation level group starting from the first free common search space candidate or after the last occupied common search space candidate within the aggregation level group.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subband #4
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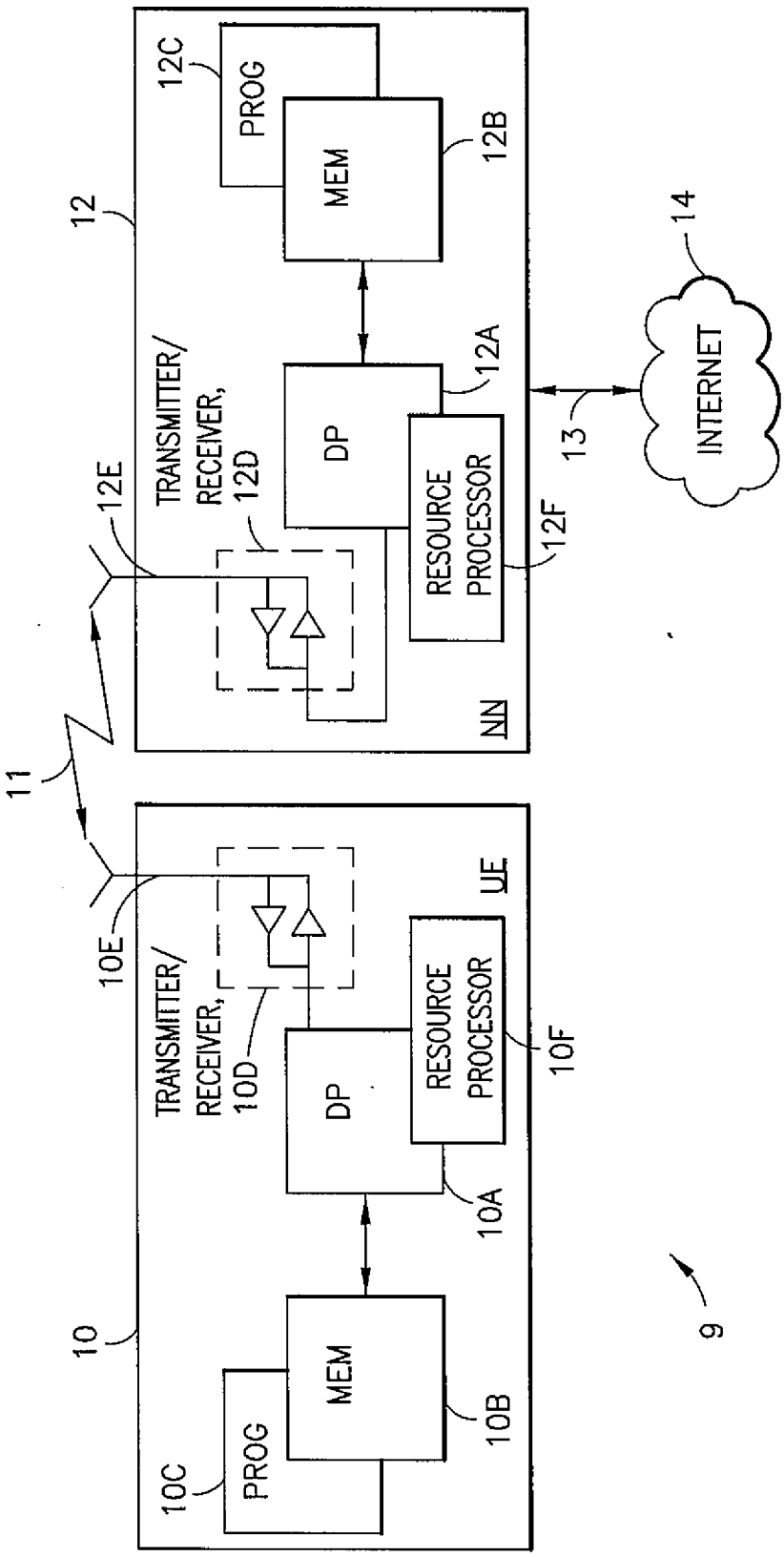
subband #3
7s-TTI
subband #2
7s-TTI
subband #1

Figure 1

2/5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PROG
MEM
12B
12A
DP
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12F
TRANSMITTER/ RECEIVER, 12D
12E
NN
13
14
INTERNET
11
10
10E
TRANSMITTER/ RECEIVER, 10D
DP
RESOURCE PROCESSOR
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UE
10A
10B
MEM
10C
PROG
9

FIG.2

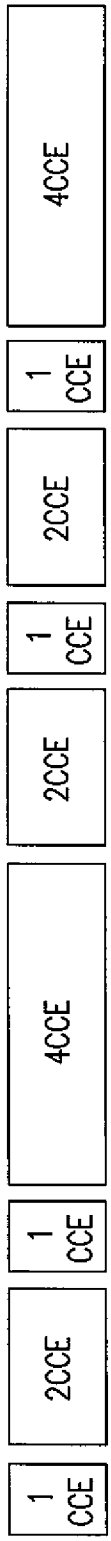

FIG.3A

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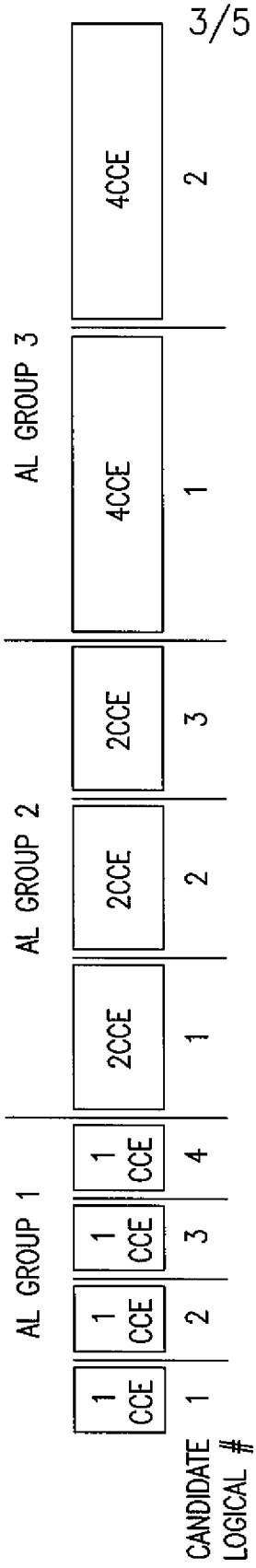

FIG.3B

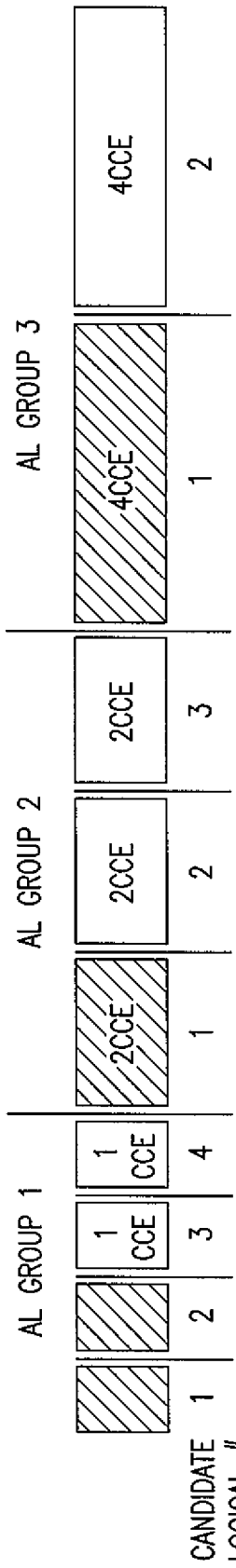

FIG.3C

4/5

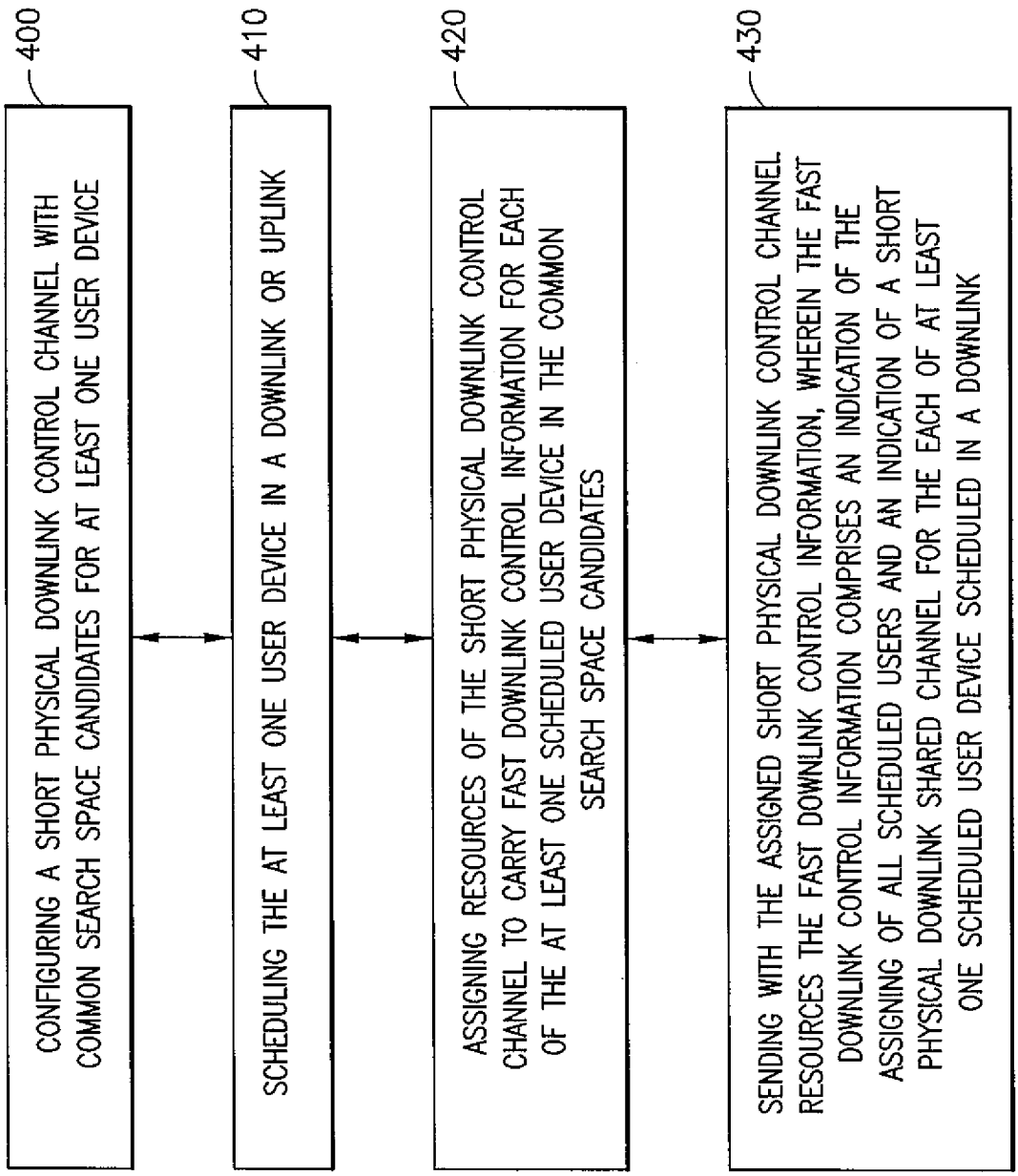
400
CONFIGURING A SHORT PHYSICAL DOWNLINK CONTROL CHANNEL WITH COMMON SEARCH SPACE CANDIDATES FOR AT LEAST ONE USER DEVICE
410
SCHEDULING THE AT LEAST ONE USER DEVICE IN A DOWNLINK OR UPLINK
420
ASSIGNING RESOURCES OF THE SHORT PHYSICAL DOWNLINK CONTROL CHANNEL TO CARRY FAST DOWNLINK CONTROL INFORMATION FOR EACH OF THE AT LEAST ONE SCHEDULED USER DEVICE IN THE COMMON SEARCH SPACE CANDIDATES
430
SENDING WITH THE ASSIGNED SHORT PHYSICAL DOWNLINK CONTROL CHANNEL RESOURCES THE FAST DOWNLINK CONTROL INFORMATION, WHEREIN THE FAST DOWNLINK CONTROL INFORMATION COMPRISES AN INDICATION OF THE ASSIGNING OF ALL SCHEDULED USERS AND AN INDICATION OF A SHORT PHYSICAL DOWNLINK SHARED CHANNEL FOR THE EACH OF AT LEAST ONE SCHEDULED USER DEVICE SCHEDULED IN A DOWNLINK

FIG.4A

5/5

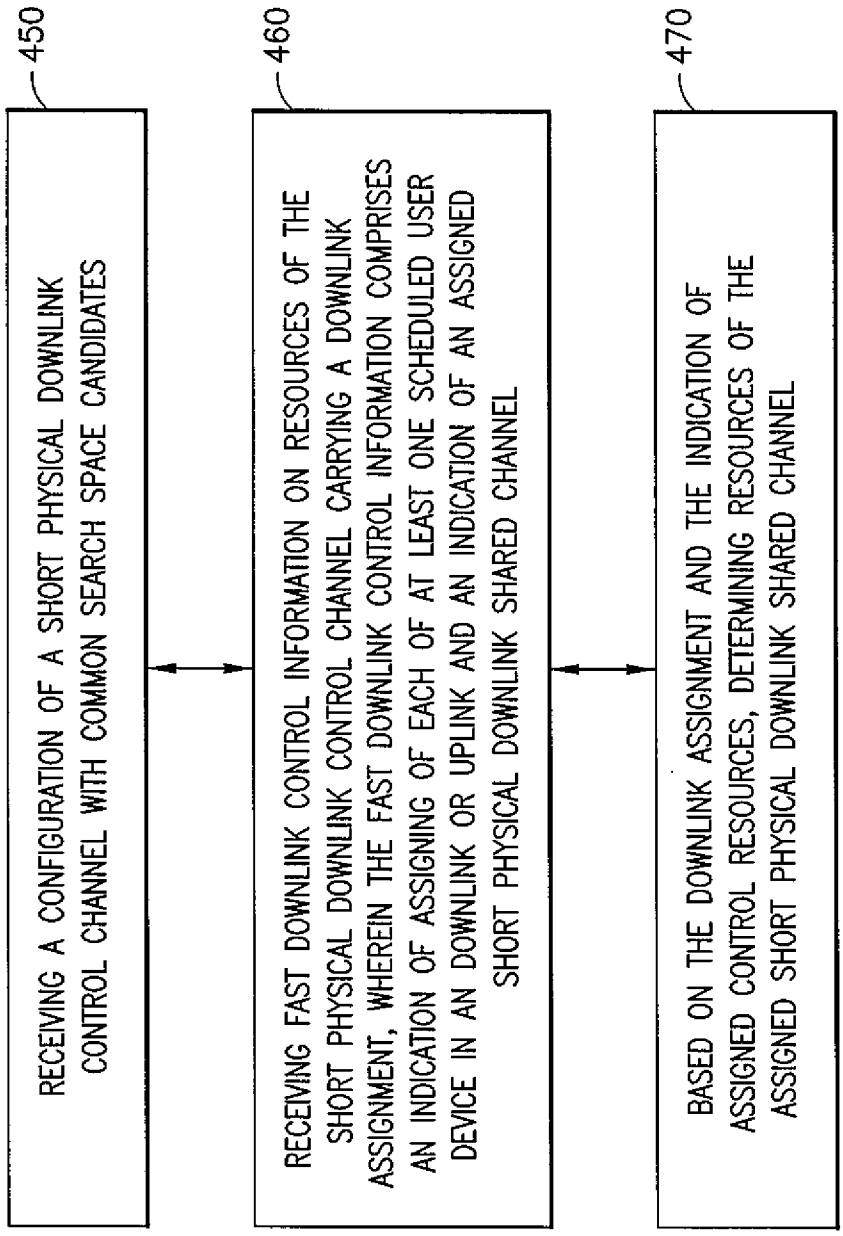
450
RECEIVING A CONFIGURATION OF A SHORT PHYSICAL DOWNLINK CONTROL CHANNEL WITH COMMON SEARCH SPACE CANDIDATES
460
RECEIVING FAST DOWNLINK CONTROL INFORMATION ON RESOURCES OF THE SHORT PHYSICAL DOWNLINK CONTROL CHANNEL CARRYING A DOWNLINK ASSIGNMENT, WHEREIN THE FAST DOWNLINK CONTROL INFORMATION COMPRISES AN INDICATION OF ASSIGNING OF EACH OF AT LEAST ONE SCHEDULED USER DEVICE IN AN DOWNLINK OR UPLINK AND AN INDICATION OF AN ASSIGNED SHORT PHYSICAL DOWNLINK SHARED CHANNEL
470
BASED ON THE DOWNLINK ASSIGNMENT AND THE INDICATION OF ASSIGNED CONTROL RESOURCES, DETERMINING RESOURCES OF THE ASSIGNED SHORT PHYSICAL DOWNLINK SHARED CHANNEL

FIG.4B

INTERNATIONAL SEARCH REPORT

International application No
PCT/IB2016/055883

A. CLASSIFICATION OF SUBJECT MATTER
INV. H04L5/00 H04W72/04
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
H04L H04W

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	NOKIA ET AL: "On DL control channel design for shorter TTI operation", 3GPP DRAFT; R1-167081_ON DESIGN OF DL CONTROL CHANNEL FOR SHORTER TTI OPERATION, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLI , vol. RAN WG1, no. Gothenburg, Sweden; 20160822 - 20160826 21 August 2016 (2016-08-21), XP051125688, Retrieved from the Internet: URL:http://www.3gpp.org/ftp/Meetings_3GPP_SYNC/RAN1/Docs/ [retrieved on 2016-08-21]	1-3,7,8, 10-14, 18,19, 21-24, 28,29, 31-34, 37,38, 40, 42-45, 48,49, 51, 53-55, 58,59,61
Y	sections 2-4	4-6,9, 15-17, 20, 25-27,

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[X] Further documents are listed in the continuation of Box C. [ ] See patent family annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
8 June 2017	21/06/2017

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Roussos, Fragkiskos

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C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
		30,35, 36,39, 41,46, 47,50, 52,56, 57,60,62

L	NOKIA ET AL: "On two-level DL control channel design for shorter TTI operation", 3GPP DRAFT; R1-167082_ON TWO-LEVEL DL CONTROL CHANNEL DESIGN FOR SHORTER TTI OPERATION, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-A , vol. RAN WG1, no. Gothenburg, Sweden; 20160822 - 20160826 21 August 2016 (2016-08-21), XP051125689, Retrieved from the Internet: URL:http://www.3gpp.org/ftp/Meetings_3GPP_SYNC/RAN1/Docs/ [retrieved on 2016-08-21] This document completes the disclosure of D1 with respect to the description of the two-level DCI control mechanism. sections 2, 4 table 2	1-3,7,8, 10-14, 18,19, 21-24, 28,29, 31-34, 37,38, 40, 42-45, 48,49, 51, 53-55, 58,59,61

X	HUAWEI ET AL: "sPDCCH design for short TTI", 3GPP DRAFT; R1-166148, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE , vol. RAN WG1, no. Gothenburg, Sweden; 20160822 - 20160826 21 August 2016 (2016-08-21), XP051125241, Retrieved from the Internet: URL:http://www.3gpp.org/ftp/Meetings_3GPP_SYNC/RAN1/Docs/ [retrieved on 2016-08-21] sections 3.4-3.5	1-3, 11-14, 22-24, 32-34, 42-45, 53-55

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C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	ERICSSON: "sPDCCH search space design", 3GPP DRAFT; R1-167487, 3RD GENERATION PARTNERSHIP PROJECT (3GPP), MOBILE COMPETENCE CENTRE ; 650, ROUTE DES LUCIOLES ; F-06921 SOPHIA-ANTIPOLIS CEDEX ; FRANCE , vol. RAN WG1, no. Gothenburg, Sweden; 20160822 - 20160826 21 August 2016 (2016-08-21), XP051125925, Retrieved from the Internet: URL:http://www.3gpp.org/ftp/Meetings_3GPP_SYNC/RAN1/Docs/ [retrieved on 2016-08-21] sections 2.1.1 - 2.1.2 -----	4-6,9, 15-17, 20, 25-27, 30,35, 36,39, 41,46, 47,50, 52,56, 57,60,62

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